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Proceeding Paper

Fruit and Vegetable Intake, and Metabolic Syndrome Components: A Population-Based Study †

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Abstract: Metabolic syndrome (MetS) risk factors have been reported in Uganda, but the role of dietary risk factors of MetS is rarely reported. This study examined the association between fruit and/or vegetable (FV) intake and MetS risk factors in adults aged 18–69 years. The data from the 2014 Uganda non-communicable diseases risk factor baseline survey was analyzed. The mean intake of FV according to the number of MetS risk factors and the odds ratios of each component according to quartiles (Q) of FV servings were computed. Overall, 1396 men and 1736 women were analyzed. The mean age was 34.4 years, the mean daily servings of total FV was 2.6 $\pm$ 0.1, and 77.7% of participants were diagnosed with at least an MetS risk factor, whereas 2.6% of participants had $\geq$3 risk factors. Men with $\geq$3 risk factors consumed less vegetable servings compared to those with one risk factor (0.9 $\pm$ 0.1 vs. 1.5 $\pm$ 0.1, $p < 0.001$). Total FV and vegetable intakes were low in women with $\geq$3 risk factors than in those with none (total FV: 1.4 $\pm$ 0.3 vs. 2.2 $\pm$ 0.3, $p = 0.003$; vegetables: 1.1 $\pm$ 0.1 vs. 1.4 $\pm$ 0.1, $p = 0.005$). Regarding individual risk factors, higher total FV intake and only fruit intake was unusually associated with higher odds of low high-density lipoprotein cholesterol (HDL-c) in men (total FV for Q1–Q4, p for trend = 0.025; fruits for Q1–Q4, p for trend = 0.03). Increasing intake of total FV was inversely associated with abdominal obesity in women (Q1–Q4, p for trend = 0.04). In conclusion, we found low consumption of vegetables in both men and women, and low consumption of total FV in women with $\geq$3 risk factors. In addition, total fruits and vegetable intake was inversely associated with abdominal obesity in women. However, the controversial finding that a high risk of low HDL-c is linked to higher FV or fruit intake in men deserves further research. The results suggest a favorable role of FV intake in MetS risk factors in this population.

Keywords: fruits; vegetables; metabolic syndrome; abdominal obesity; adults; Uganda

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1. Introduction

Low fruit and vegetable (FV) intake is a risk factor for cardiovascular disease (CVD) mortality and ischemic heart disease (IHD). The highest global burden of disease attributed to insufficient FV consumption is observed in low- and middle-income countries [1]. Metabolic syndrome (MetS), a cluster of abdominal obesity, hypertension, fasting hyperglycemia and dyslipidemia, increases the risk of CVD [2,3]. An increase in the global prevalence of MetS has been reported [4,5], and Uganda is not exceptional. Although nationwide data are lacking, a rural-based survey reported the prevalence of MetS at 19% in Uganda [6]. The prevalence of MetS components has also been reported, with low−high-density lipoprotein cholesterol (HDL-c), hypertension, and abdominal obesity being the most prevalent metabolic risk factors [7].

Several epidemiological studies have reported the link between FV intake and MetS development. FV intake is inversely associated with MetS [8,9] and a reduction in abdominal obesity [10,11]. The relationship between FV intake and MetS or its risk factors has mostly been explored in countries outside Sub-Saharan Africa. However, FV intake varies considerably among countries [1]. In Uganda, only 12% of the population consume five or more servings of FV per day [12]. Considering the low consumption of FV in Uganda, the relationship between FV intake and health outcomes warrants investigation. This study investigated the cross-sectional association between FV consumption and MetS risk factors using the 2014 Uganda non-communicable disease (NCD) risk factor survey.

2. Materials and Methods

2.1. Study Participants

The Uganda national NCDs risk factor baseline survey was conducted between March and July 2014 to determine the magnitude of NCDs and their risk factors in Uganda. The details of the survey methodology have been published elsewhere [7] and is briefly described here. The standard World Health Organization (WHO) STEPS tool for NCDs risk factor surveillance was used to collect data for this national survey [13]. The STEPS involves a sequential process that starts with the gathering of information on key risk factors using a questionnaire (STEP 1), followed by simple physical measurements (STEP 2) and biochemical assessments (STEP 3). A multi-stage sampling design was used to select a nationally representative sample of participants aged 18–69 years. Of the 3987 individuals who were surveyed, we excluded participants with missing data on MetS (n = 12), covariates (n = 22), FV intake (n = 5), history of chronic diseases or being on treatment for chronic diseases (n = 646), and pregnant women (n = 170), yielding a final analytical sample of 3132 participants: 1396 men and 1736 women.

2.2. MetS Risk Factors

Individuals were categorized based on the number of MetS components as 0, 1, 2, and $\geq$3 components. Satisying three or more of the following criteria was used to diagnose MetS: (1) average systolic blood pressure of $\geq$140 mmHg or diastolic blood pressure of $\geq$90 mmHg or being on regular antihypertensive medicine; (2) fasting high-density lipoprotein cholesterol (HDL-c) of $\leq$40 mg/dL for men and $\leq$50 mg/dL for women; (3) fasting plasma glucose of $\geq$100 mg/dL or drug treatment for elevated fasting blood glucose; (4) waist circumference (WC) of $\geq$102 cm in men or $\geq$88 cm in women.

2.3. FV Consumption

FV intake was assessed by asking participants the number of days in a typical week when they ate fruits and/or vegetables and the number of servings of fruit or vegetables eaten on one of those days. Serving sizes were illustrated using nutrition cards. The reported number of servings for each item was summed together to compute the average fruit and/or vegetable servings. Fruit, vegetable, and combined FV intake (servings/day) were converted into quartiles.

2.4. Covariates

Covariates were evaluated as follows: educational level (no formal education, primary, secondary, or university level and above); alcohol use (current users: consumption of any type of alcohol during the 30 days preceding the survey or past/never users); tobacco use (current users or past/never users). The short version of the WHO Global Physical Activity Questionnaire (GPAQ) v2.0 was used to assess physical activity [14]. Based on the GPAQ protocol, participants were categorized into low, moderate, and high physical activity levels.

2.5. Statistical Analysis

Data were analyzed using Proc survey procedures for complex survey data in SAS version 9.4 (SAS Institute, Cary, NC, USA). Results are least square means (LSM) $\pm$ standard errors (SE) for continuous variables and percentages for categorical variables. The mean daily servings of fruits, vegetables, and total FV were compared across participant characteristics and the number of MetS risk factors using the general linear model adjusted for multiple comparisons. Multivariable logistic regression models were used to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) of the associations between FV intake and each MetS component. Statistical significance was tested using p-values of <0.05.

3. Results

The relationship between FV intake and participants' characteristics is displayed in Table 1. The intake of more vegetables was associated with old age, and the women consumed less servings of fruits and total FV. Compared to Baganda, the Basoga and Lugbara/Madi/Iteso/Karimajong consumed more FV only in men, while the Bagisu/Sabiny/other tribes consumed more vegetables among women. The Lugbara/Madi/Iteso/Karimajong consumed more fruits than the Baganda, but more vegetables were consumed by the rest of the ethnicities except Banyankole/Bakiga and Banyoro/Batooro among men. On the other hand, more vegetable intake was linked to never alcohol use in men and past alcohol use in women. Moreover, moderate physical activity was associated with the consumption of more vegetables and total FV in men.

Table 1. Mean servings of total fruits and vegetables, fruits, and vegetables according to participants' characteristics.

Characteristic	Men (1396)				Women (1736)			
	%	Total FV	Fruits †	Vegetables ††	%	Total FV	Fruits †	Vegetables ††
Age, years								
18–29	45.6	2.5 ± 0.1	1.5 ± 0.1	1.0 ± 0.1 [a]	48.1	2.7 ± 0.1	1.5 ± 0.1	1.2 ± 0.1 [a]
30–49	39.6	2.5 ± 0.2	1.3 ± 0.1	1.2 ± 0.1	38.3	2.8 ± 0.1	1.3 ± 0.1	1.5 ± 0.1 *
50–69	14.8	2.7 ± 0.2	1.1 ± 0.2	1.6 ± 0.2 *	13.5	3.2 ± 0.4	1.5 ± 0.3	1.7 ± 0.2 *
Highest education level attained								
No formal education	6.9	2.3 ± 0.3	0.9 ± 0.2	1.4 ± 0.2	22.0	2.5 ± 0.2	1.2 ± 0.2	1.2 ± 0.1
Primary	41.8	2.4 ± 0.2	1.4 ± 0.1	1.1 ± 0.1	40.3	3.0 ± 0.2	1.5 ± 0.2	1.5 ± 0.1
Secondary	39.4	2.5 ± 0.2	1.3 ± 0.1	1.2 ± 0.1	32.0	2.9 ± 0.2	1.4 ± 0.2	1.4 ± 0.1
University and above	12.0	2.7 ± 0.3	1.5 ± 0.2	1.3 ± 0.2	5.7	2.4 ± 0.3	1.2 ± 0.2	1.3 ± 0.2
Employment in the past year								
Unemployed	29.7	2.5 ± 0.1	1.2 ± 0.1	1.1 ± 0.1	46.9	3.0 ± 0.2 [a]	1.5 ± 0.2 [a]	1.4 ± 0.1
Employed	70.3	2.5 ± 0.1	1.4 ± 0.1	1.2 ± 0.1	53.1	2.6 ± 0.1 [b]	1.3 ± 0.1 *	1.4 ± 0.1
Ethnicity								
Baganda	15.7	2.0 ± 0.2 [a]	1.2 ± 0.1 [a]	0.8 ± 0.1 [a]	13.5	2.7 ± 0.4	1.4 ± 0.2	1.3 ± 0.2 [a]
Banyankole/Bakiga	23.0	1.7 ± 0.1	0.7 ± 0.1 *	1.1 ± 0.1	23.8	2.0 ± 0.1	0.9 ± 0.1	1.1 ± 0.1
Basoga	10.7	3.0 ± 0.3 *	1.7 ± 0.2	1.3 ± 0.1 *	11.3	3.5 ± 0.3	1.9 ± 0.3	1.7 ± 0.1
Banyoro/Batooro	10.7	2.2 ± 0.2	0.9 ± 0.1	1.2 ± 0.2	11.9	2.1 ± 0.2	1.0 ± 0.1	1.1 ± 0.1
Lango/Padhora/Alur	15.0	2.1 ± 0.2	0.9 ± 0.1	1.4 ± 0.2 *	17.7	2.4 ± 0.2	0.9 ± 0.1	1.6 ± 0.2
Lugbara/Madi/Iteso/Karimajong	18.2	3.8 ± 0.5 *	2.7 ± 0.5 *	1.2 ± 0.1 *	14.7	4.1 ± 0.5	2.8 ± 0.5	1.4 ± 0.1
Bagisu/Sabiny/others	6.8	3.3 ± 0.3	1.3 ± 0.2	2.0 ± 0.2 *	7.1	3.7 ± 0.5	1.6 ± 0.3	2.2 ± 0.3 *
Marital status								
Single/divorced/separated	34.2	2.6 ± 0.2	1.5 ± 0.2	1.1 ± 0.1	34.1	2.9 ± 0.2	1.5 ± 0.2	1.3 ± 0.1
Married/cohabiting	65.8	2.5 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	65.9	2.8 ± 0.1	1.3 ± 0.1	1.4 ± 0.1
Tobacco use								
Never/past user	83.0	2.5 ± 0.1	1.3 ± 0.1	1.2 ± 0.1	95.1	2.8 ± 0.1	1.5 ± 0.1	1.4 ± 0.1
Current user	17.0	2.5 ± 0.2	1.3 ± 0.2	1.3 ± 0.1	4.9	1.7 ± 0.2	0.5 ± 0.2	1.4 ± 0.2
Alcohol use								
Never user	41.9	2.7 ± 0.2	1.3 ± 0.1	1.4 ± 0.1 [a]	63.6	2.8 ± 0.1	1.5 ± 0.1	1.3 ± 0.1 [a]
Current user	38.2	2.3 ± 0.1	1.3 ± 0.1	1.1 ± 0.1	17.7	2.6 ± 0.2	1.2 ± 0.2	1.5 ± 0.1
Past user	19.8	2.4 ± 0.2	1.5 ± 0.2	1.0 ± 0.1 *	18.7	2.8 ± 0.3	1.2 ± 0.2	1.7 ± 0.2 *
Moderate physical activity								
No	5.2	1.7 ± 0.3 [a]	1.0 ± 0.2	0.8 ± 0.1 [a]	7.0	2.6 ± 0.3	1.3 ± 0.2	1.3 ± 0.1
Yes	94.8	2.5 ± 0.1 *	1.4 ± 0.1	1.2 ± 0.1 *	93.0	2.8 ± 0.1	1.4 ± 0.1	1.4 ± 0.1
BMI category								
Underweight	10.9	2.6 ± 0.3	1.5 ± 0.1	1.3 ± 0.2	7.4	2.3 ± 0.3	1.0 ± 0.1	1.5 ± 0.2
Normal weight	76.9	2.5 ± 0.1	1.2 ± 0.2	1.2 ± 0.1	66.6	2.8 ± 0.1	1.5 ± 0.2	1.4 ± 0.1
Overweight/obese	12.2	2.5 ± 0.3	1.2 ± 0.2	1.4 ± 0.2	26.0	2.6 ± 0.2	1.0 ± 0.2	1.4 ± 0.1

Means were adjusted for age. Dunnett's test was used for multiple comparisons. * Significantly different from [a]. FV, fruit and vegetable; † 1378 Men and 1719 women were analyzed; †† 1393 Men and 1732 women were analyzed.

Table 2 shows the average daily servings of FV according to the number of MetS risk factors. Men with ≥3 risk factors consumed less servings of vegetables than those with 1 and 2 risk factors (LSM ± SE: 0.9 ± 0.1 vs. 1.5 ± 0.1 for men with ≥3 risk factors vs.

those with one risk factor; LSM ± SE: 0.9 ± 0.1 vs. 1.4 ± 0.1 for men with ≥3 risk factors vs. those with two risk factors; $p < 0.001$), while women with ≥3 risk factors consumed few vegetable servings than those with 2 risk factors (LSM ± SE: 1.1 ± 0.1 vs. 1.7 ± 0.1; $p < 0.001$). However, the total FV intake was higher in women that were diagnosed with no MetS risk factors than in those that were diagnosed with ≥3 risk factors (LSM ± SE: 2.2 ± 0.3 vs. 1.4 ± 0.3).

Table 2. Average daily servings of FV according to the number of metabolic syndrome (MetS) risk factors.

	Number of MetS Risk Factors									
	Men					**Women**				
	0 *n* **= 415**	**1** *n* **= 775**	**2** *n* **= 200**	**≥3** *n* **= 06**	***p*-Value**	**0** *n* **= 390**	**1** *n* **= 925**	**2** *n* **= 335**	**≥3** *n* **= 86**	***p*-Value**
Total FV	1.9 ± 0.3	2.2 ± 0.2	2.5 ± 0.2	1.3 ± 0.3	0.12	2.2 ± 0.3 [a]	2.4 ± 0.2 [a]	2.6 ± 0.2 [a]	1.4 ± 0.3 [b]	0.003
Vegetables	1.3 ± 0.1 [ab]	1.5 ± 0.1 [a]	1.4 ± 0.1 [a]	0.9 ± 0.1 [b]	<0.001	1.4 ± 0.1 [ab]	1.6 ± 0.1 [ab]	1.7 ± 0.1 [a]	1.1 ± 0.1 [b]	0.005
Fruits	1.1 ± 0.2	1.1 ± 0.2	1.5 ± 0.2	0.7 ± 0.2	0.49	1.5 ± 0.2	1.5 ± 0.2	1.5 ± 0.2	0.9 ± 0.2	0.070

Means were adjusted for age, education, employment and race, smoking, alcohol intake, and physical activity. Scheffe was used for multiple comparisons, and values with different superscript letters were significantly different.

Table 3 shows the association between FV intake and MetS risk factors in men. The ORs of low HDL-c increased with the increasing intake of total FV servings (ORs for Q1−Q4: 1.73, 95% CI: 1.04–2.87, p for trend: 0.025) and fruit servings (ORs for Q1−Q4: 1.43, 95% CI: 0.92–2.23, p for trend: 0.037).

Table 3. Odds ratios (ORs) and 95% confidence intervals (CIs) of MetS risk factors by quartiles of FV intake in men.

	Total FV			**Fruits**			**Vegetables**		
	Yes	**No**	**OR (95% CI) †**	**Yes**	**No**	**OR (95% CI)**	**Yes**	**No**	**OR (95% CI)**
Abdominal obesity	06	1357		06	1258		06	1258	
Per IQR of servings/day [1]			0.61 (0.21–1.75)			0.80 (0.43–1.47)			0.48 (0.12–1.90)
High blood pressure	349	1018		343	1008		348	1016	
Q1	102	288	1.00	89	249	1.00	106	293	1.00
Q2	76	248	0.96 (0.58–1.60)	80	273	1.00 (0.62–1.62)	88	331	0.63 (0.40–1.00)
Q3	79	265	0.68 (0.42–1.10)	84	240	1.01 (0.59–1.74)	66	197	1.16 (0.72–1.86)
Q4	92	217	1.20 (0.73–1.97)	90	246	1.14 (0.68–1.92)	88	195	1.17 (0.73–1.86)
p for trend			0.482			0.560			0.133
High blood glucose	55	1232		55	1216		55	1230	
Q1	19	357	1.00	13	307	1.00	16	364	1.00
Q2	09	287	0.47 (0.20–1.11)	16	312	1.17 (0.40–3.41)	13	384	0.56 (0.22–1.41)
Q3	17	315	1.02 (0.41–2.52)	16	295	1.16 (0.43–3.15)	17	229	1.17 (0.44–3.10)
Q4	10	273	0.56 (0.23–1.38)	10	302	0.66 (0.23–1.94)	09	253	0.81 (0.28–2.34)
p for trend			0.357			0.286			0.974
Low high-density lipoprotein cholesterol (HDL-c)	782	505		775	496		780	505	
Q1	220	156	1.00	183	137	1.00	72	46	1.00
Q2	170	126	1.12 (0.74–1.69)	192	136	0.87 (0.57–1.32)	127	64	1.02 (0.69–1.52)
Q3	212	120	1.50 (0.96–2.36)	198	113	1.23 (0.80–1.90)	88	45	1.27 (0.81–2.00)
Q4	180	103	1.73 (1.04–2.87)	202	110	1.43 (0.92–2.23)	85	66	1.06 (0.66–1.69)
p for trend			0.025			0.037			0.680

[1] Modelled continuous variable because of very few cases in each quartile. † Adjusted for age, education, employment, race, smoking, alcohol intake, and physical activity.

Table 4 shows the association between FV intake and MetS risk factors in women. The intake of FV was inversely associated with abdominal obesity (p for trend: 0.044).

Table 4. ORs and 95% CIs of MetS risk factors by quartiles of FV intake in women.

	Total FV			Fruits			Vegetables		
	Yes	**No**	**OR (95% CI) †**	**Yes**	**No**	**OR (95% CI)**	**Yes**	**No**	**OR (95% CI)**
Abdominal obesity	301	1395		299	1383		300	1392	
Q1	86	330	1.00	76	381	1.00	62	283	1.00
Q2	69	342	0.94 (0.61–1.45)	91	349	1.26 (0.76–2.09)	100	422	1.16 (0.74–1.81)
Q3	83	350	0.84 (0.55–1.30)	69	309	0.78 (0.46–1.31)	65	323	1.01 (0.61–1.69)
Q4	63	373	0.63 (0.39–1.02)	63	344	0.76 (0.46–1.24)	73	364	0.95 (0.58–1.56)
p for trend			0.044			0.078			0.607
High blood pressure	364	1340		364	1326		364	1336	
Q1	100	317	1.00	122	337	1.00	75	272	1.00
Q2	86	328	0.67 (0.43–1.05)	100	343	0.88 (0.58–1.34)	109	416	0.98 (0.63–1.54)
Q3	87	348	0.71 (0.43–1.18)	64	316	0.65 (0.41–1.03)	74	315	0.72 (0.39–1.31)
Q4	91	347	0.82 (0.54–1.26)	78	330	0.83 (0.51–1.34)	106	333	1.01 (0.65–1.56)
p for trend			0.728			0.550			0.962
High blood glucose	75	1551		75	1535		75	1548	
Q1	17	384	1.00	18	418	1.00	16	315	1.00
Q2	29	367	1.62 (0.69–3.79)	27	404	0.98 (0.41–2.35)	25	477	1.25 (0.59–2.64)
Q3	15	405	0.44 (0.16–1.20)	19	343	0.91 (0.39–2.14)	19	352	0.87 (0.37–2.05)
Q4	14	395	0.78 (0.32–1.88)	11	370	0.45 (0.17–1.21)	15	404	0.77 (0.31–1.95)
p for trend			0.245			0.062			0.306
Low HDL-c	1120	506		1113	497		1117	506	
Q1	279	122	1.00	288	148	1.00	241	139	1.00
Q2	268	128	0.86 (0.57–1.30)	303	128	1.12 (0.78–1.61)	239	158	1.18 (0.77–1.80)
Q3	290	130	1.01 (0.66–1.56)	259	103	1.25 (0.81–1.93)	153	93	0.98 (0.64–1.49)
Q4	283	126	1.10 (0.73–1.64)	263	118	1.09 (0.74–1.59)	147	115	1.34 (0.86–2.07)
p for trend			0.416			0.881			0.283

† Adjusted for age, education, employment, race, smoking, alcohol intake, and physical activity.

4. Discussion

We investigated the association between FV intake and MetS risk factors using nationwide survey data. We reported that having ≥3 MetS risk factors was associated with low vegetable intake in men and women, but low total FV intake only in women. In addition, total FV intake was inversely associated with abdominal obesity in women, consistent with previous research [10,11]. However, FV intake, in particular fruits intake, was positively associated with low HDL-c in men.

The positive association of FV intake and low HDL-c in men could be explained by possible reverse causation and residual confounding from total energy intake, urban/rural residence, and menopausal status. This finding deserves further exploration. Notably, lack of data on triglycerides precluded MetS diagnosis. Nevertheless, the study provides preliminary data on the association of FV intake and markers of MetS diagnosis in Uganda using population-based data.

5. Conclusions

These results suggest a benefit of FV intake in MetS and a need to consider strategies for promotion of FV intake with particular attention to women. Studies with data on all MetS components and potential confounders are needed to confirm these results.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Publicly available datasets were analyzed in this study. Upon request, this data can be found here: https://extranet.who.int/ncdsmicrodata/index.php/catalog/633.

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